Taketo NAKANO*: **Some soil algae from the Senkaku Islands, Ryukyus, Japan****

中野武登*: 尖閣列島の土壌藻類

We have only a little information concerning soil algae of the Ryukyus (Akiyama 1970). Akiyama (1970) studied algae isolated from soils of Okinawa and Ishigaki Islands, part of the Ryukyus, and reported 47 species representing 41 genera.

From March 29, 1971 to April 10, 1971, a scientific investigation of the Senkaku Islands was made by the investigation committee of the University of Ryukyus. In this investigation, some soil samples were collected from Uotsuri-jima and Kobi-sho Islands by Mr. Y. Miyagi of Hiroshima University (at the present time, of the University of Ryukyus). I isolated algae from those soil samples in laboratory culture. As a result of the study, considerable numbers of algal species were detected, and are reported here.

Materials and methods The Senkaku Islands situated at 25°40′-25°57′N. latitude and 123°30′-124°35′E. longitude, are in the East China Sea, southwest of the Ryukyu Islands. These islands consist of some small islands and reefs, such as Uotsuri-jima, Kita-kojima, Minami-kojima, Kobi-sho and Sekibi-sho, which are all uninhabited. Uotsuri-jima Island is about 3 km in length and 1 km in width, covering an area of about 4 km^2 with a coastline of 11.028 km. The rock of this island consists of conglomeratic sandstone, andesite and recent raised coral reef (Nohara 1971). In this island, nine plant communities were observed, in which *Livistona chinensis* var. *subglobosa-Arenga engleri* community was dominant (Niiro et al. 1971). Kobi-sho Island is a round volcanic island with a coastline of 3.491 km. The rock of this island consists of pumice, lava flow and andesite (Nohara 1971). In this island, ten plant communities were found, of which the prevailing one was *Livistona chinensis* var. *subglobosa-Pisonia umbellifera* community. Data of soil samples used in this study are

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listed in Tab. 1.

Two grams from each sample were mixed with 20 ml sterile water. After sufficient stirring, a part of its supernatant was poured onto agar plates containing Bold's Basal Medium (1N BBM; Bischoff & Bold 1963). These culture vessels were placed in the culture room at 22±1°C under the illumination of approximate 3000 lux on a cycle of 12 hr light and 12 hr darkness. After 2 to 3 weeks, unialgal colonies became visible on the agar plates. These colonies were transferred to BBM agar slants and cultured under the above mentioned conditions. Afterward, axenic cultures were obtained by the method of Wiedeman et al. (1964). Identification of the algae was made from these isolates.

Result ane discussion Of the 32 taxa identified, seven are Cyanophyceae, 20 Chlorophyceae, two Bacillariophyceae and three Chrysophyceae (see the following list). The most predominant species in both Uotsuri-jima and Kobi-sho Islands were *Chlorococcum echinozygotum*, *Bracteacoccus* sp., *Chlorella vulgaris*, *Stichococcus bacillaris*, *Klebsormidium flaccidum* and *Botrydiopsis arhiza*. They have been well known as members of soil algae in the world and also were frequently isolated from Japanese soils (Akiyama 1965, 1966, 1970, Akiyama & Nishigami 1970, Nakano 1971, Watanabe 1977).

In Uotsuri-jima Island, colors of soils were brown, black brown or black and pH values showed acidic trend, 4.7–5.7. Great numbers of species were isolated from Sample UO-335 which was collected from a forest edge of *Livistona chinensis* var. *subglobosa-Arenga engleri* community, while few (only two or three species) were isolated from Sample UO-330, 331, 333, 336 and 337 which were collected from forest floors of the same community. In Kobi-sho Island, colors of soils were black or black brown and pH values showed acidic trend, 5.9–6.3. Many species were isolated from Sample KO-338 which was collected from a grass land, while only a small number of species were isolated from Samples KO-339, 340, 341, 342 and 343. These samples were collected from forest floors of *Livistona chinensis* var. *subglobosa-Pisonia umbellifera* community, *Crepidiastrum lanceolatum-Lilium longiflorum* community or bare land. According to a study by Nakano (1981) on a correlation between the standing crop of edaphic algae and organic carbon contents of the soils in Mt. Daisen, Tottori Prefecture, soils of the sites with no or poor development of overground macrovegetation had both more diverse algal components and larger standing crops than soils under better-developed forests. Results of the present study also

Tab. 1. Summary of data on the samples studied on the Senkaku Islands.

Sample No.	Collection date	Locality	Soil		Vegetation
			color	PH	
UO-330	2. Apr. 1971	Uotsuri-jima	black	5. 6	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-331	2. Apr. 1971	Uotsuri-jima	brown	4. 7	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-332	2. Apr. 1971	Uotsuri-jima	black	5. 1	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-333	2. Apr. 1971	Uotsuri-jima	brown	5. 4	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-334	2. Apr. 1971	Uotsuri-jima	black-brown	5. 2	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-335	2. Apr. 1971	Uotsuri-jima	black-brown	5. 7	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-336	2. Apr. 1971	Uotsuri-jima	black-brown	—	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
UO-337	2. Apr. 1971	Uotsuri-jima	black-brown	5. 5	*Livistona chinensis* var. *subglobosa-Arenga engleri* community
KO-338	6. Apr. 1971	Kobi-sho	black-brown	6. 1	grass land
KO-339	6. Apr. 1971	Kobi-sho	black-brown	6. 3	*Livistona chinensis* var. *subglobosa-Pisonia umbellifera* community
KO-340	6. Apr. 1971	Kobi-sho	black-brown	5. 9	*Crepidiastrum lanceolatum-Lilium longiflorum* community
KO-341	6. Apr. 1971	Kobi-sho	black	—	*Livistona chinensis* var. *subglobosa-Pisonia unbellifera* community
KO-342	6. Apr. 1971	Kobi-sho	black	6. 3	*Livistona chinensis* var. *subglobosa-Pisonia umbellifera* community
KO-343	6. Apr. 1971	Kobi-sho	black	—	bare land

showed the same tendency as to algal components in soils except of Sample KO-343 (bare land). Soils from bare lands generally have more diverse algal components than forest soils, but that of the sample of KO-343 was rather poor. This fact is supposed to be caused by the properties of soil composed of congromerate clay which generally has poor algal components.

Akiyama (1970) reported 47 species of soil algae from the Ryukyu Islands. Compared with the results of his study, the Senkaku Islands has poor components of soil algae. This fact may be caused by the difference of habitat of collection sites. Namely, the soil samples studied by Akiyama were mostly collected from cultivated lands, waste lands and mangrove forest floors which generally have rich algal components or unusual algal species. On the other hand, in the present study, samples were mainly collected from forest floors which generally have poor algal components. In the Senkaku Islands, there were no cultivated lands.

Four species isolated (*Chlorococcum minutum* Starr, *Podohedra distincta* Geitler, *Stichococcus mirabilis* Lagerheim and *Chlorocloster raphidioides* Pascher) were newly found in Japan. Concerning them, detail descriptions are made in the following list.

List of species

Cyanophyceae

1. *Phormidium tenue* (Menegh.) Gomont
   Sample examined: KO-338.
2. *P. corium* (Ag.) Gomont
   Sample examined: UO-335.
3. *P. valderianum* (Delp.) Gomont
   Sample examined: KO-340.
4. *Nostoc punctiforme* (Kuetz.) Hariot
   Sample examined: KO-338.
5. *Nostoc.* sp.
   Samples examined: UO-334, 335; KO-338, 342, 343.
6. *Plectonema nostocorum* Bornet ex Gomont
   Sample examined: KO-338.
7. *Westiellopsis prolifica* Janet
   Samples examined: UO-332, 334, 335.

Chrysophyceae

8. *Monodus subterranea* Boye-Petersen

   Samples examined: UO-334, 335.

9. *Chlorocloster raphidioides* Pascher in Rabenhorst's Krypt-Fl. 11: 463, fig. 324 (1937). (Figs. 1-4)

   Cells solitary, fusiform slightly bent or sigmoid, with sharply pointed ends 2.5-4.5 μm in width, 15-22 μm in length. Chloroplast parietal, trough-shaped, without pyrenoid. Oil droplets present, numerous. Reproduction by autospores.

   Sample examined: KO-338.

   This alga agreed well with the original description and figure by Pascher (1937). This species resembles *Keratococcus raphidioides* (Hansg.) Pascher, but differs from it by the absence of a pyrenoid. Pascher (1937) found this alga on a border of a pond, in a drain and in soil. In this study, the alga was isolated from only one soil sample collected from a grass land in Kobi-sho Island.

   This species is newly found in Japan.

10. *Botrydiopsis arhiza* Borzi

    Samples examined: UO-330, 332, 334, 335; KO-338, 343.

Bacillariophyceae

11. *Pinnularia borealis* Ehr.

    Sample examined: KO-338.

12. *Hantzschia amphioxys* (Ehrenb.) Grunow

    Samples examined: UO-334; KO-338.

Chlorophyceae

13. *Chlamydomonas* sp.

    Samples examined: UO-332, 334; KO-338, 343.

14. *Chlorococcum echinozygotum* Starr

    Samples examined: UO-332, 334, 335; KO-338, 340, 342, 343.

15. *C. minutum* Starr in Comparative Study *Chlorococcum* Menegh.: 30, figs. 81-103 (1955). (Figs. 5-14)

    Cells solitary, spherical to subspherical, sometimes ovoid, 4-5 μm in diameter in young cultures, 7-12 μm in two-week-cultures, with thin cell wall. In stationary phase cultures, spherical cells reaching a maximum size of 20 μm, with walls of 2-3 μm thickness. Two contractile vacuoles sometimes present. Chloroplast parietal, hollow sphere, with a single, excentric pyrenoid covered with continuous starch sheath. Asexual reproduction by zoospores and aplanospores.

Zoospores 2-3 μm in width, 5-6 μm in length, with rounded ends, with anterior stigma and two anterior contractile vacuoles and a posterior nucleus. Sexual reproduction by isogametes. Zygospores not observed.

Sample examined: UO-334.

This alga agreed well with the original description and figures of Starr (1955). Archibald (1970) reported vegetative cells with thick cell walls, 5-6 μm in stationary phase cultures, while Starr (1955) observed cells with walls of about 2 μm in thickness in old cultures. My observation was similar to Starr's description. I could not observe vegetative cells with thicker cell wall such as reported by Archibald (1970) at any culture ages. Starr (1955) observed zygospores having smooth cell wall and protoplast filled with oil, but I could not see such cells after union of gametes. Therefore I could not distinguish zygospores from ordinary vegetative cells.

This alga was originally isolated from soil from Bombay, India by Starr (1955). In this study, it was isolated from only one soil sample collected from a forest floor of *Livistona chinensis* var. *subglobosa-Arenga engleri* community.

This species is newly reported from Japan.

16. *Chlorococcum* sp.

Sample examined: KO-343.

17. *Hormotilopsis gelatinosa* Trainor et Bold

Samples examined: UO-335; KO-338.

18. *Trebouxia* sp.

Sample examined: KO-338.

19. *Bracteacoccus* sp.

Samples examined: UO-330, 331, 333, 334; KO-340, 341, 342.

20. *Chlorella vulgaris* Beijerinck

Samples examined: UO-331, 332, 334, 335, 336, 337, KO-338, 339, 341.

21. *C. luteoviridis* Chodat

Sample examined: UO-335.

22. *C. saccharophila* (Krueg.) Migla

Sample examined: KO-338.

23. *Palmellococcus reniformis* (Watanabe) S. Watanabe

Sample examined: KO-340.

24. *Podohedra distincta* Geitler in Österr. Bot. Z. 112: 176, figs. 1, e-g, 3, a-c (1965). (Figs. 15, 16)

Cells solitary, attached to the substrate by one elongate basal end, fusiform, heteropolar, flexed to sigmoid, 4.5-6 μm in width, 45-80 μm in length, toward the apical end gradually narrowed and sharply pointed. Basal end slightly extended, as long as apical end or slightly longer than apical end. Cell wall smooth, hyaline, without mucilaginous envelopes. Chloroplast parietal, trough-shaped, with distinct pyrenoid. Oil droplets present. Reproduction by 2-4 autospores, released by longitudinal rupture of mother cell wall.

Sample examined: UO-335.

This alga agreed well with the original description and figures of Geitler (1965) in the shape of vegetative cells. In cell shape, this species is similar to *Podohedriella carpatica* Hindak but differs from it by the presence of a pyrenoid.

This alga was isolated from only one soil sample which was collected from a forest edge of *Livistona chinensis* var. *subglobosa-Arenga engleri* community in Uotsuri-jima Island.

This species is newly found in Japan.

25. *Scotiellopsis terrestris* (Reisigl) Punčochářová et Kalina

Samples examined: KO-338, 340.

26. *Chlorosarcinopsis* sp.

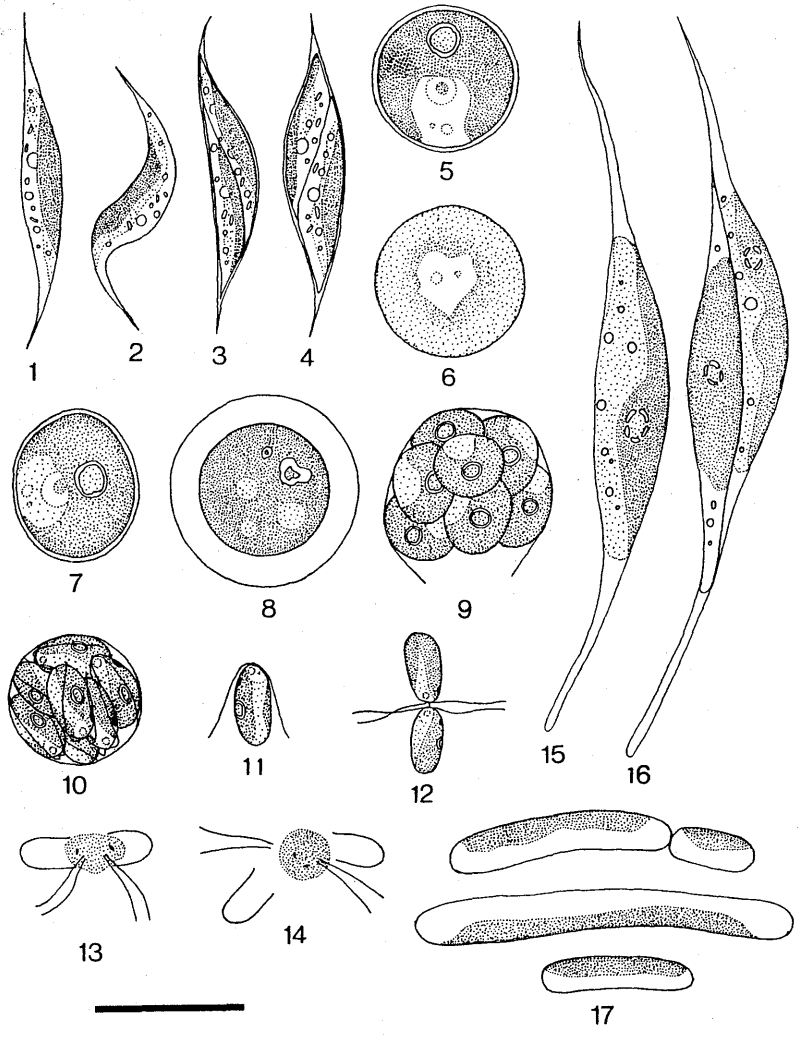
Samples examined: UO-332; KO-338.

27. *Stichococcus mirabilis* Lagerheim in Wittrock et Nordstedt, Alg. aqu. dulc. exsicc., fasc. 23, No. 1087 (1893); Heering, in Pascher's Süsswasserfl. 6: 53, fig. 69 (1914). (Figs. 17)

Cells solitary, sometimes attached in pairs, straight or slightly curved, cylindrical with rounded end, 2-4 μm in width, 6-29 μm in length. Cell wall thin, smooth. Chloroplast parietal, plate-like, filling only half of the cell periphery. Pyrenoid indistinct. Oil droplets and starch grains not observed. Reproduction by fragmentation.

Samples examined: UO-335; KO-343.

Although the type specimen could not be observed in this study, this alga agreed well with the description and figures of Heering (1914) and Ramanathan (1964). The present alga grew excellently in BBM medium. Cells were remarkably variable according to the culture age. In the youngest cultures, they were slender, while in log phase cultures, about 2 to 3 weeks cultures, they became large in size as mentioned above. Ramanathan (1964) reported the



Figs. 1-4: *Chlorocloster raphidioides.* 1, 2, vegetative cells. 3, 4, autosporangia. Figs. 5-14: *Chlorococcum minutum.* 5, median optical section of spherical vegetative cell. 6, surface view of same cell. 7, ovoidal vegetative cell. 8, old cell with thickend cell wall. 9, aplanosporangium. 10, zoosporangium. 11, zoospore or gamete. 12-14, stage in union of isogametes. Figs. 15, 16: *Podohedra distincta.* 15, vegetative cell. 16, autosporangium. Fig. 17: *Stichococcus mirabilis.* Scale bar: 10 μm.

change of colony shapes according to the culture age, and the present alga also showed the same changes.

Although this alga has hitherto been recorded from aquatic habitats (Bourrelly 1953), it was, in this study, isolated from an aerial habitat for the first time. This alga was isolated from two soil samples (UO-335, KO-343). These samples were collected from a forest edge of *Livistona chinensis* var. *subglobosa-Arenga engleri* community in Uotsuri-jima Island and a bare land in Kobi-sho Island respectively.

This species is newly found in Japan.

28. *S. bacillaris* Naegeli
    Samples examined: UO-332, 333, 334, 335, 337; KO-338, 340, 343.
29. *Klebsormidium flaccidum* (Kuet.) Silva, Mattox et Blackwell
    Samples examined: UO-332, 334, 335; KO-338, 340, 343.
30. *Leptosira terricola* (Bristol) Prinz.
    Samples examined: UO-330, 334, 335.
31. *Desmococcus vulgaris* (Naegeli) Brand
    Sample examined: KO-340.
32. *Protosiphon botryoides* (Kuetz.) Klebs
    Samples examined: UO-334, 335; KO-338.

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尖閣列島の土壌が1971年4月2日と4月6日に琉球大学の宮城康一氏により採取された。これを分与されたので土壌藻類の分離を試みた。その結果，藍藻類7種，黄緑色藻類3種，珪藻類2種，緑藻類20種，合計32種の藻類を分離することができた。これらの藻類のリストを掲げるとともに，日本新産4種（*Chlorococcum minutum* Starr, *Podohedra distincta* Geitler, *Stichococcus mirabilis* Lagerheim, *Chlorocloster raphidioides* Pascher）について記載を付した。